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NASA National Space Grant College and Fellowship Program

***Final Report: 2001 – 2005 of the Hawai'i Space Grant
Consortium***

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A handwritten signature in black ink, appearing to read 'Luke Flynn', is written over a horizontal line.

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I. Executive Summary 2001 - 2005

The Hawai'i Space Grant Consortium is composed of ten institutions of higher learning including the University of Hawai'i at Manoa, the University of Hawai'i at Hilo, the University of Guam, and seven Community Colleges spread over the 4 main Hawaiian islands. Geographic separation is not the only obstacle that we face as a Consortium. Hawai'i has been mired in an economic downturn due to a lack of tourism for almost all of the period (2001 - 2004) covered by this report, although hotel occupancy rates and real estate sales have sky-rocketed in the last year. Our challenges have been many including providing quality educational opportunities in the face of shrinking State and Federal budgets, encouraging science and technology course instruction at the K-12 level in a public school system that is becoming less focused on high technology and more focused on developing basic reading and math skills, and assembling community college programs with instructors who are expected to teach more classes for the same salary.

Motivated people can overcome these problems. Fortunately, the Hawai'i Space Grant Consortium (HSGC) consists of a group of highly motivated and talented individuals who have not only overcome these obstacles, but have excelled with the Program. We fill a critical need within the State of Hawai'i to provide our children with opportunities to pursue their dreams of becoming the next generation of NASA astronauts, engineers, and explorers. Our strength lies not only in our diligent and creative HSGC advisory board, but also with Hawai'i's teachers, students, parents, and industry executives who are willing to invest their time, effort, and resources into Hawai'i's future. Our operational philosophy is to FACE the Future, meaning that we will *facilitate, administer, catalyze, and educate* in order to achieve our objective of creating a highly technically capable workforce both here in Hawai'i and for NASA. In addition to *administering* to programs and *educating* the public in the traditional sense, we also work to *facilitate* partnerships between other departments (geology & geophysics, engineering, geography, astronomy), state and federal government agencies in Hawai'i, and private industry. In some cases, we are the *catalyst* for new partnerships between private agency sponsors and education projects or for new joint research and education projects between industry and the University faculty.

Central to the HSGC program is our version of NASA's educational objective to build an educational pipeline for high technology. The Hawai'i Science, Technology, Engineering, and Mathematics Pipeline (HiSTEM) consists of 3 branches in the areas of Space Science, Engineering, and Remote Sensing that offer activities from the K-12 to the graduate level. We recognize the need to engage student interest in engineering and science at a young age and so HiSTEM is designed to provide hands-on interactive and engaging programs at every level of education.

HiSTEM is anchored by our K-8 programs that are centered on the Future Flight Hawai'i program. Future Flight Hawai'i, celebrating its 13th year, places children within a team of peers having to solve problems in a space mission scenario. Future Flight Hawai'i is so successful that registration for the summer program fills up in January! To answer the call for more programs of this sort, we sponsor hands-on learning opportunities through Family Science Nights, classroom visits, and the Ellison Onizuka and Lacy Veach Days of Discovery that have reached over 10,000 students, parents, and teachers in a single year. Community support for Future Flight Hawai'i programs has been outstanding with Universities and private schools donating facilities and personnel to host events, and local businesses (American Savings Bank and Hawaiian Electric Company) and educational

organizations donating monetary and personnel resources to provide high tech exhibits and engaging hands-on learning opportunities.

Next, at the 9-12 grade level, we have the FIRST Robotics program. High school students and high tech industry volunteers from the community form teams to build robots to accomplish tasks. Our program has grown from 2 underrepresented schools 3 years ago to 6 today and more astoundingly from 32% female team members to 76% this year! That means more women and underrepresented students in the workplace as engineers in the future.

We are fortunate in that UH-Manoa has a very strong research base in the fields of Geology and Geophysics, Astronomy, and Engineering that has led to the development of a robust HSGC Fellowship Program. All of our research fellows *must* have projects that have a connection to NASA's research objectives. We started the traineeship program to provide Community College students with research opportunities. Next, we are working with local businesses to provide *internships* on high tech projects. The HSGC would provide a \$3000 stipend for one semester of support at the start of the internship. The private company would then provide at least one semester of support for the intern for the next semester to match HSGC support. Dr. John Pye has also been successful with starting an internship program for Maui CC students involving the Maui High Performance Computing Center, Boeing, Oceanit, Trex, and the W.M. Keck Observatory.

Our interactions with the College of Engineering have created many research opportunities for undergraduates. The centerpiece of this is the CubeSat small satellite program started here in 2001. CubeSat is partially sponsored by HSGC workforce development funds. The purpose of the program is to design, build, test, and launch a small (10 cm x 10 cm x 15 cm) satellite into space by 2005. This remarkable program is mentored by electrical and mechanical engineering faculty but is driven entirely by undergraduate engineering students. Fifty-four students formed 6 design teams to work on the project. This is a challenging project that requires careful organization, project management, and fund raising. The students were successful in obtaining a \$100,000 NASA/Air Force grant to build a similar Nanosat satellite. CubeSat Project Director Aaron Ohta won the 2003 Alton B. Zerby and Carl T. Koerner Outstanding Electrical Engineering Student Award. In fact, CubeSat Project Director Blaine Murakami won the same award in 2005 meaning that the Hawai'i CubeSat team has turned out the nation's best Electrical Engineer in 2001, 2003, and 2005. As a result of CubeSat success, the HSGC sponsors related CanSat projects at the Maui, Honolulu, Windward, and Kapiolani Community Colleges.

In response to the needs of the local high tech industries, the HSGC developed a Master Plan for workforce development to be accomplished in three stages. Stage 1 initially includes providing three levels of educational outreach and training along three separate technical tracks. We have increased our technical course offerings at the University level and are developing shorter week-long GeoSTAC modules to accomplish Stage 1. Stage 2 focuses on University/government/corporate sector joint proposals. We have successfully written a \$10 million proposal with NovaSol here in Hawai'i to use the International Space Station to study coral reef health and volcanic eruptions. Stage 3 of the plan results from stage 2 as specialized courses and teaching personnel within the University are added. NovaSol and STI have also committed to a Master's Apprenticeship program in which graduate students would work on company-relevant projects and have a thesis committee consisting of UH faculty and industry representatives.

II. Introduction to Final Report 2001 - 2005

Chartered under the National Space Grant College and Fellowship Program, the Hawai'i Space Grant Consortium (HSGC) is developing interdisciplinary education, research, and public service programs related to space science, earth science, remote sensing, human exploration, and development of space and aerospace technology. We accomplish this through a variety of programs: undergraduate research fellowships, traineeships, and internships, innovative college courses, workshops for educators, educational web sites, public exhibitions, lectures, tours, primary school programs, and space-themed summer camps for families.

The need for a high-technology literate workforce is greater than ever before. In "Inspiring the Next Generation of Explorers", NASA's Education Enterprise Strategy, Code N officials recognize that 60% of NASA's workforce is science or engineering-based and half of those employees have Masters or Doctoral degrees. As a result of 9/11 and the establishment of the Office of Homeland Security, the demand for highly technically skilled workers has also grown at a much faster rate than that originally anticipated by NASA's introspective analysis. Since the tragedy of 9/11, Hawai'i high tech businesses have grown nearly exponentially (40 new Masters and PhD-level employees at Nova Sol, Inc. alone in the last 2.5 years).

Traditionally, the HSGC remained focused on research experiences related to space science and remote sensing, but, in alignment with NASA's educational focus as well as the 1996-2000 Space Grant Educational Priorities, our objectives have shifted to include engineering. To organize new engineering projects, we have added an Associate Director for Aerospace Engineering, Dr. Carlos Coimbra. Our program-sponsored philosophy also had to change to become more dynamic in response to new national priorities. Our new HSGC philosophy is summed up with the phrase FACE the Future (facilitate, administer, catalyze, educate). In the traditional sense, the HSGC educated the public through a variety of programs and administered to many others. We now recognize that if we attempt to administer to all high tech programs, that our expansion will be limited by HSGC personnel constraints. Thus, in addition to *administering* to programs and educating the public in the traditional sense, we will also work to *facilitate* partnerships between other departments (engineering, geography, astronomy), state and federal government agencies in Hawai'i, and private industry. In some cases, we will be the *catalyst* for new partnerships between private agency sponsors and education projects (CRESSPO, Botball, Pacific Missile Range CubeSat launches) or for new joint research and education projects between industry and the University faculty.

The HSGC program is rapidly expanding to accommodate the seven Space Grant Educational Priorities.

- (1) *Form new partnerships between Engineering, all levels of educational institutions, government and industry.* In the last five years, robotics and engineering have been our areas of most rapid expansion. In 2000, the FIRST robotics program included industry partnering with local underrepresented high school students. The HSGC sponsored the undergraduate-led CubeSat small satellite program in 2001 within the College of Engineering. In 2002, the HSGC fostered partnerships with private companies for "extended fellowships" by developing the internship and Master's apprenticeship programs. We have also added Associate Director for Aerospace

Engineering, Dr. Carlos Coimbra (Mechanical Engineering) who will organize the CubeSat and other satellite programs for the HSGC.

- (2) *Provide undergraduate training at the University level as well as NASA Field Centers and Industry.* The cornerstones of the HSGC undergraduate training experience includes the mentor-student fellowship research and industry-student internship programs. Research fellows applying from the community colleges or main UH-Manoa and UH-Hilo campuses must submit a NASA-related project for review. Most importantly, we interact with the department of education to provide undergraduate pre-service teaching experiences using high tech examples. We have also had undergraduates participate in the programs at various NASA Centers.
- (3) *Stress development of interdisciplinary courses and curriculum.* GG 101, 168, and GIS 150 are introductory and interdisciplinary courses designed to pique student interest in high tech careers.
- (4) *Enhance precollege teacher education to include science and engineering disciplines.* All of our workshops and undergraduate courses for teachers concentrate on both science and engineering, and how teachers can incorporate these subjects into their curricula. Our workshops are now given during the school year, giving teachers the opportunity (often required by us!) to test drive new activities and their new knowledge. We have worked closely with the Bishop Museum, most prominently on playing a crucial role in creating a large exhibit called "Extreme Science: Oceans, Volcanoes, and Outer Space."
- (5) *Develop community college initiatives in distance learning as well as GPS and GIS.* Our community colleges are full partners in our educational programs. Community college students have worked on fellowship projects with mentors on their campuses as well as UH-Manoa. We are excited to expand the role of the community colleges to include the 5-campus (Windward, Honolulu, Leeward, Kapiolani, Maui) CanSat program, which will be run concurrently with CubeSat. A number of community colleges (Honolulu, Kapiolani, Windward, and Leeward) are also interested in a jointly-taught distance learning course in Astrobiology. Dr. Joe Ciotti at the Windward campus teaches a course in GPS/GIS technology, while we have developed a follow-on course with Workforce Development funds at the UH-Manoa campus.
- (6) *Focus on diversity: Women, underrepresented minorities, and persons with disabilities.* The University of Hawai'i is a minority university. The many programs focused on diversity are listed in section III.1 below as well as the individual program areas in section IV.
- (7) *Develop instructional technology, technology transfer, and other technological courses that use NASA technology.* We accomplish this in two ways: (1) our courses such as GG 460 (Table 4) offer remote sensing instruction using NASA data from the MODIS, ETM+, and EO-1 missions, and (2) *ALL* of our undergraduate fellowships must use NASA data or technology for their research.

One of NASA's educational objectives is to build and maintain an educational pipeline that includes provisions for Science, Technology, Engineering, and Mathematics (STEM). To increase STEM participation at the undergraduate level requires captivating student interest at the pre-college and even elementary school level. The HSGC has developed the HiSTEM program (Table 1) with strong educational pipelines to propel the technical learning

experience from elementary school to Master's level post-graduate degrees. HiSTEM has many built-in feeder or entry points for students to access the pipeline, but we are now working also to expand these access points as much as possible. For example, Future Flight Hawai'i (FFH, henceforth) has been a highly successful program where student explorers learn space science, remote sensing, and engineering. Family Science Nights, based on FFH modules and hands-on activities, were developed to further involve parents and children in the high tech learning process and to make the FFH experience available to thousands more students, parents, and teachers.

Table 1. HiSTEM: Hawai'i Science, Technology, Engineering, and Mathematics

Level	Engineering	Remote Sensing	Space Science
K-8	Future Flight Hawai'i Family Science Night Botball	Future Flight Hawai'i Family Science Night WELES/KaAMS	Future Flight Hawai'i Family Science Night Girl Scouts
9-12	FIRST NASA SHARP CHART	EAST NASA SHARP CHART	NASA SHARP CHART
Community College	SG Traineeships SG Internships CanSat	SG Traineeships SG Internships GIS 100 (Ciotti)	SG Traineeships GG 108
Undergraduate	SG Fellowships SG Traineeships SG Internships CubeSat NASA Academy	SG Fellowships SG Traineeships SG Internships GG 460 NSCI 494 GG 671: GIS/GPS NASA Academy	SG Fellowships GG 108 GG 168 NSCI 494 Astrobiology NASA Academy
Graduate	Master's Apprenticeship	Master's Apprenticeship	GG 673: Moon, Mars GG seminars in advanced topics

In 2002, the HSGC submitted a Workforce Development plan that expanded the HiSTEM pipeline by adding the CHART program, more funds for CubeSat, a GPS/GIS course, and created a blue print for how University and industry partnerships could occur. Workforce interactions were divided into three stages: (1) Educational Outreach and Training including on-line course development and interaction on joint student projects facilitated by the HSGC, (2) Joint research projects having University and industry investigators, and (3) Dynamic expansion of faculty and specialized courses as a result of specific educational requirements. Meetings with two Oahu high tech companies (STI, Inc. and NovaSol) have led to fruitful discussions about (1) a joint UH-industry Master's Apprenticeship program for engineering and geology students, (2) a new type of Space Grant Fellowship called an internship where undergraduate students work with industry mentors on corporate projects, (3) joint research proposals, (A space station-based coral reef and volcano monitoring project submitted with NovaSol is slated to receive \$2 million this year of a total of \$10 million of which \$500,000 will go to the HSGC to support student and faculty research. A joint UH-STI NSF proposal is pending approval and would net an additional \$240,000 over 3 years for the study of sequestration of lava in active flow fields.) and (4) industry participation in curriculum development.

In the sections below, we highlight the achievements of the last five years. We have taken great strides to expand the breadth of our program and have endeavored to cover this adequately hereafter.

III. National Program Emphases

In this section, we indicate how the HSGC incorporated each of the cross-cutting national program emphases into our program. Detailed discussions of the implementation are reserved for the appropriate Program Element section (Part IV below).

III.1 Diversity

The University of Hawai'i system including the University of Hawai'i at Hilo is a minority institution. We encourage participation of women, underrepresented minorities, and persons with disabilities in all aspects of our program. Starting at the top, the HSGC management includes numerous women and minority Executive and Associate Directors. FFH Program Director Arthur Kimura was able to attract a Women and Technology grant in the amount of \$50,000 (and advises spending of a further \$75,000) which supports the participation of women high school students in a variety of high tech programs. This includes sponsorship of a largely female engineering team for the FIRST robotics program at Waiakea High School on the Big Island of Hawai'i. For the past three years we sponsored four high schools (Waiakea, Waipahu, Waialua and McKinley) to participate in the FIRST robotics program. These schools were chosen because of a large population of underrepresented student body. Female participation in this program has increased tremendously for the past three years. In year one, 32% of the participating students were female, year two 67%, and year three 76%. For four years, Educational Specialist Rene Kimura provided extensive hands-on science activities at the annual GEMS (Girls Engaged in Math and Science) conference. There were 708 women who participated of which 44% are considered underrepresented. In 1998, we sponsored a Multi-Sensory Teachers' Workshop. This workshop is to train teachers in the use of a kit of materials, developed with NASA funding, for use in classes for the learning disabled. We encourage participation of women and underrepresented minorities in our CubeSat, FFH, undergraduate fellowship, traineeship, and internship programs. In the past 5 years, 3 minority students, Aaron Ohta, Kendall Ching, and Blaine Murakami have won the nationally-competed Alton B. Zerby and Carl T. Koerner Outstanding Electrical Engineering Student award. Another Hawai'i Space Grant fellowship recipient, Mr. Cory Soon, won the 2003 Research Corporation of the University of Hawai'i's "Student Excellence in Research Award". Our programs and courses are held in facilities that are fully handicapped accessible. We are working towards online courses that will allow for greater participation of persons with disabilities. Finally, our web site is fully 508-compliant allowing for access by blind persons.

III.2 Competitiveness

Hawai'i Space Grant Consortium programs are made available to as wide a pool of potential applicants as possible. Pre-college programs including FFH, the FIRST robotics program, the Lacy Veach/Ellison Onizuka Science Discovery Days, and Family Science Nights are administered on a first-come, first-served basis. A panel of HSGC officials including the Director, Executive Director, and Associate Directors judge the undergraduate fellowship and traineeship projects. Criteria for judging are the feasibility of the project, the NASA-related objective of the project, and the applicant's grade point average (GPA > 3.0 generally required). Other Space Grant funds are made available to affiliates based on competitive review of proposed statements of work. Space Grant proposals for research efforts are similarly reviewed by the HSGC Executive Committee (Director, Luke Flynn; Program Coordinator, Marcia Rei Sistoso; Former Director and current Associate Director,

Jeff Taylor) for NASA-connection, sustainability (program continuity based on resource support), capacity (number of individuals served) and relevance to program objectives.

III.3 NASA Ties

In spite of the large distance between the nearest NASA Centers and Hawai'i, we have been involved in several significant projects with almost all of the NASA Centers. We have sent students to the NASA Academy at Goddard, Dryden, and Ames.

Johnson Space Center: We are actively involved with JSC (Marilyn Lindstrom, Jackie Allen) on revising the teacher guides that accompany the lunar and meteorite educational disks. We also collaborated with JSC and the Lunar and Planetary Institute (LPI) on the LPI's broker/facilitator program (funded by the Office of Space Science). Jeff Taylor's research has established a collaborative effort with Dr. David McKay's group at the Johnson Space Center, focusing on the search for Martian soil in meteorites from Mars. JSC also provided a educational specialist for FFH and Space Shuttle food and trays for presentations.

Jet Propulsion Laboratory: Jeff Taylor has been involved in several projects with JPL. (1) Review of the Mars Exploration Program E/PO strategy. (2) Attended a workshop on defining the goals of a mission to analyze the atmosphere and surface of Venus. (3) Serves on the Executive Committee of the Mars Exploration Program Assessment Group, which is managed by JPL. Art Kimura received funding from JPL to develop "Satellite in a Shoebox," a project involving communication between pairs of schools. Art Kimura served 4 years as a member of the Mars Educational Advisory Committee.

Dryden Flight Research Center: We worked closely with Dryden and Pennsylvania Space Grant on developing online educational projects. One was the online implementation of WELES (Web Enhanced Learning Environment Strategies), a lesson-planner that gives teachers a way to access online materials about remote sensing. The other was an elaborate hands-on web site called Kids as Airborne Mission Scientists (KaAMS) which provides lesson plans for simulated volcano and coral reef data collection missions. In addition, we organized and coordinated participation of 25 teachers in a special NASA Education Workshop at Dryden (Marianne McCarthy). Dryden also sponsored a NASA Education Workshop for 27 educators partially in support of the Pathfinder flight program on Kauai.

Ames Research Center: Jeff Taylor worked closely with Ames on developing a well-received E/PO plan for a proposal submitted to NASA's Discovery program (Space Science). The mission, *Polar Night*, was inadvertently not chosen by NASA. Taylor and Linda Martel had also worked with Ames on the Lunar Prospector education program, including conducting workshops for teachers prior to the launch in 1997. Art Kimura worked with Ames to provide Aerospace Educations specialists for Onizuka and Veach Science Days and NASA education materials for K-12 teacher support.

Applied Physics Laboratory: Like JPL, APL is not quite a NASA Center, but it serves as one for some space science and earth science missions. Jeff Taylor is Principal Investigator on a proposal to retrieve samples from the South Pole-Aitken basin on the farside of the Moon. Called *Farside*, the mission will have an extensive E/PO program, which will be led by Aileen Yingst, Director of Wisconsin Space Grant.

Goddard Space Flight Center: Luke Flynn has served as a science team member for both the Landsat 7 and Earth Observing -1 missions. During the Landsat mission, he was the educational representative for the team and was tasked with developing ways to use Landsat data for classroom instruction. He gave a talk to 270 California educators at Vandenburg Air Force Base shortly before the launch of Landsat 7 in 1999.

Kennedy Space Center: Special behind the scenes tour of facilities for HSGC staff.

Glenn, Ames, and Marshall Research Centers: Art Kimura interacted with the Aerospace Education section to obtain classroom materials for a variety of topics.

III.4 Industry Relations

The HSGC maintains healthy collaborative efforts with Hawai'i high tech businesses. Mr. Paul Featherland serves as an industrial affiliate from the Hawaiian Electric Company. Eventually, we would hope to have other representatives from local industries serve as associate directors on our steering committee. Nova Sol representatives have asked to be part of the Engineering and School of Ocean and Earth Science Technology (SOEST) curriculum development committees because they would like to hire graduates with relevant skills sets. Associate Director John Pye is working with the Center for Adaptive Optics in UC Santa Cruz to provide 7-week internships for Maui Community College students with industry partners including the Maui High Performance Computing Center, Boeing, Oceanit, Trex, and the W. M. Keck Observatories. He is also working with the Maui Optical System and Imaging Center to provide student training in preparation for high tech careers. The HSGC has embarked on a Workforce Development program that will include a new type of fellowship, the internship, where HSGC fellowship students will become part-time employees of high tech companies. Both Nova Sol and STI, Inc. on Oahu have agreed to serve as mentors for the internship program where students work at the company a few days a week and complete company-relevant research projects. Last year, we were successful in placing two apprentices at NovaSol for the summer. In addition, we have established the Master's Apprenticeship Program in which a joint committee of UH faculty and industry researchers will fund and oversee thesis projects. We have written joint proposals with two companies (Coral reef and volcano studies from the International Space Station, NovaSol; NSF Lava flow sequestration using high spatial resolution hyperspectral data, STI) to obtain federal funds for ourselves as well as our industry partners. Jeff Taylor is also working closely with Boeing Aerospace (Huntington Beach and El Segundo, California) on the Farside mission. This will lead to research opportunities for our students.

III.5 State Government Involvement

We have had a long-standing collaboration with the Hawai'i Department of Education in organizing weekend Space Conferences. These are an offshoot of FFH, and involve students, teachers, and parents. State budget problems have caused a loss of funding for this program, but our collaboration continues in other areas. We also collaborate with individual schools (Kaneohe, Keaau, Chiefess Kapiolani, Nanaikapono and Gus Webling Elementary Schools), placing emphasis on those serving minorities and disadvantaged students. Chiefess Kamakahelei and Waimea Middle Schools were selected among 50 nation wide middle schools to participate in the NASA Explorer Schools program. Space Grant was instrumental in informing and encouraging these two schools to apply to the program. The Explorer School coordinators had participated in Space Grant activities. Space Grant's Educational Specialist Art Kimura was invited to accompany the teams as a consultant for the Explorer Schools Training at Ames Research Center. He will assist the schools in developing and implementing their three-year action plans. HSGC also works closely with the state's Department of Business and Economic Development and Tourism (DBEDT). This collaboration has led to proposals to NASA (so far not funded), such as one to become a Commercial Center for Remote Sensing and Data Analysis. At the request of DBEDT, we agreed to host the annual Universities Space Systems Symposium last year which brings

together undergraduate engineering students from the United States and Japan to work on sophisticated aerospace engineering projects.

IV. Program Elements

IV.1 Consortium Management

Description

The HSGC is composed of the University of Hawai'i system including the Community Colleges, the University of Hawai'i at Hilo, and the University of Guam. The participating Community Colleges that have associate directors are Hawai'i, Honolulu, Kapiolani, Leeward, Maui, and Windward. Presently, we do not have an Associate Director for the Kauai campus and are in the process of searching for a representative. In September 2002 at an Associate Directors' meeting attended by all except Dr. Mark Lander, the HSGC management approved a retroactive change (to July 1, 2002) in the Director position from Dr. Jeff Taylor to Dr. Luke Flynn. At that time, we also formed an executive committee (This consists of Director Flynn, Executive Director, Ms. Lorna Ramiscal, and Past Director Taylor who is now the Associate Director for Space Science) to handle the increasing volume of HSGC business and to take advantage of the combined corporate knowledge that Ms. Ramiscal and Dr. Taylor have of the national Space Grant program. In August 2004, Ms. Ramiscal left her position with the HSGC. Ms. Marcia Rei Sistoso was hired as Program Coordinator for the HSGC and replaced Ms. Ramiscal on the HSGC executive committee. The executive committee meets at least once per week to discuss new HSGC business, to evaluate and decide on new proposed activities, to plan new strategy in response to changing NASA and national Space Grant objectives, and to allocate tasks for the week. In 2003, we added two new associate directors at Leeward Community College, Drs. Kakkala Mohanan and Roger Kwok. Also, Dr. Sun Park took over responsibility for the UH-Hilo program from Dr. Barbara Gibson. Our HSGC-sponsored engineering programs are growing rapidly as a result of the successful CubeSat program and our workforce development initiatives. For this reason, we have added Associate Director for Aerospace Engineering, Dr. Carlos Coimbra. Table 2 summarizes the HSGC advisory board that includes the associate directors from the Community Colleges as well as a group of specialized associate directors from UH-Manoa plus FFH Program Director, Arthur Kimura. The entire advisory board meets at least twice a year to discuss HSGC policy changes as well as propose and discuss new directions for the HSGC. Smaller meetings occur at the Manoa campus or another venue more often. Consortium Management accounts for ~ 20% of the total HSGC budget.

Table 2. The HSGC Advisory Board summarized by campus.

University of Hawai'i, Manoa, Lead Campus: Director: Luke Flynn Program Coordinator: Marcia Rei Sistoso Associate Director, Space Science: G. Jeff Taylor Associate Director, Aerospace Engineering: Carlos Coimbra Associate Director, Fellowships: Edward Scott Associate Director, Outreach: B. Ray Hawke Program Director, Future Flight Hawaii: Arthur Kimura	Kaua'i Community College: Associate Director: TBD
UH Hilo: Associate Director: Sun Park	Kapi'olani Community College: Associate Director: John Rand
Hawai'i Community College: Associate Director: Bernard Laurich	Leeward Community College: Associate Director: Kakkala Mohanan Associate Director: Roger Kwok
Honolulu Community College: Associate Director: Ronald Takata	Maui Community College: Associate Director: John Pye
	Windward Community College: Associate Director: Joseph Ciotti
	University of Guam: Associate Director: Mark Lander

Core Criteria

Consortium Operations. The HSGC office moved at about the time of our change in the HSGC Director position last year. The HSGC office moved from the basement of Sinclair Library to a larger (~900 sq. ft.) office space at the Pacific Ocean and Science Technology (POST) building. The move was extremely important because the building also houses the Geology and Geophysics Department, Computer Sciences Department, and the College of Engineering faculty offices. This central location has played a pivotal role in our increased interaction with engineering students. Within this singularly-accessed area, we have separate offices for the Director, Program Coordinator, Program Director for Future Flight, computer area for student helpers and undergraduate fellows, and a storage area. Additional separate offices were made available for Associate Directors Taylor, Scott, and Hawke, so the actual office space that the HSGC occupies on the 5th floor of POST is much larger. Our central office phone number, supported with a phone recorder and manned by student helpers, is 808-956-3138. We received an offer through Program Director Kimura to use the Hawai'i Convention Center nearly free of charge for special programs. Punahou School and UH-Hilo regularly provide space for the Ellison Onizuka and Lacy Veach Science Days of Discovery. Kauai CC provides facilities for our FFH program.

The Hawai'i State Legislature created two half-time faculty and one full-time administrative post as support for the positions of Director, Associate Director, and Executive Director/Program Coordinator of the HSGC, respectively. However, we only receive funds to support the two faculty positions at the present time. Up to June 30, 2002, both G-funded positions were used to support Director Jeff Taylor. Since that time, one half-time position is used to support Director Luke Flynn, while the other is used to support Jeff Taylor's Associate Director position. An additional two months of HSGC support are provided to Jeff Taylor and Luke Flynn. The Executive Director, later Program Coordinator, Ms. Lorna Ramiscal, later Ms. Marcia Rei Sistoso, draws all of her salary from the HSGC. This is inaccurately summarized in CMIS Table III.B which lists, among other errors, no FTE support for any positions in 1999. We have affiliate representatives (Associate Directors) at each of the seven Community Colleges. We have maintained affiliations with the community colleges with a very mixed degree of effectiveness, which depends on the zeal of the individual for the position as well as the amount of time that they have for Space Grant. Windward CC is a strong HSGC partner with their own aerospace lab, planetarium, and GIS courses. Maui CC is building strong links to industry (See III.4) and is a constant source of new program ideas. Honolulu CC faculty assist with the FFH program and are instrumental in the CanSat program. At present, there is no representative at Kauai Community College, but we are working to correct that. We are especially excited to have two energetic Associate Directors at Leeward Community College with a Chancellor who is solidly behind the HSGC program. Dr. Mohanan will continue to operate the public and student observatory program there, while Mr. Roger Kwok will continue to provide instruction at FFH and engage undergraduates in research projects at Leeward. We have had trouble maintaining liaisons with UH-Hilo and Hawai'i CC. Dr. Sun Park has now taken over at UH-Hilo and maintains strong research links with Manoa. Each community college associate director gets 3 credits of release time to accomplish HSGC tasks.

We have an advisory board that consists of the individuals listed in Table 2. We meet at least twice a year, meeting at the undergraduate fellows' symposia, which are held once per semester. Meetings are almost always held at the Manoa campus, but we intend to hold one

meeting at another campus in the future. This will allow all of us to become more familiar with the other campuses. The general directions that the consortium takes and our approach to funding is determined democratically by the board, although key leadership responsibilities remain with the Executive Committee. The advisory board participated actively in developing and approving our strategic plan (available online at <http://www.spacegrant.Hawaii.edu>), and will ensure that it is always up to date. In principle, the board is available to settle disputes between affiliates or between an affiliate and consortium management, but we have not had to submit any issues to arbitration. This lack of controversy may stem from a combination of all consortium members feeling they have a voice in how we operate and all board members agreeing on broad policies. Our board meetings are lively open discussions that have lasted for 4 – 6 hours at a time as we creatively seek ways to improve programs and educate Hawai'i.

Resource Management. The consortium is managed from the University of Hawai'i at Manoa, the state's only research institution. All campuses receive a base funding level (about \$5000/year plus 3 credits of release time for the Associate Director to accomplish HSGC functions on their campus) to carry out their main functions; this base funding includes an allocation for fellowships. As the largest campus, Manoa receives the largest amount of funding. The rest of the funding is divided approximately equally among the other campuses, though we set aside some money (usually about \$25 k) for special projects. These funds are awarded in a consortium-wide competition. We believe that the combination of a reasonable base level of funding coupled with supplemental funding for the most innovative projects is a sound approach. The CMIS Table entitled Allocation of Funds Across Affiliates shows this. Affiliates receive no additional funds if they have not used their previous allotment. In this table, University of Hawai'i, Hilo Campus and University of Hawai'i at Hilo are the same which we call UH-Hilo in this report. UH-Hilo received roughly 3 times the funding of the other affiliates because of the larger number of undergraduate research projects. Windward CC has received separate support from NASA to build and maintain the Aerospace Lab and a planetarium which is why their allocation is higher.

In 1998 – 1999, matching funds came primarily from State of Hawai'i G-fund support for Jeff Taylor's salary and an overhead return waiver granted from the UH-Manoa. We are fortunate that UH-Manoa has a very strong research base which means that we can leverage monies from other Federal projects for research as well as education. The LUAU I&II projects netted the HSGC an additional \$321,709 over 3 years to develop educational lesson plans. A new project to study the health of the world's coral reefs has been approved by Congress and will receive \$2 million of \$10 million total in FY 2004. The HSGC will receive ~\$500,000 of this for undergraduate fellowships, internships, and research. However, with waning State support available due to a long term economic downturn, we have seen a full overhead waiver on the main HSGC award turn into a \$25,000 return of overhead. Since that time, contributions from local business for the astronaut science days, and contributions of teachers' time for FFH have shored up our matching funds.

CMIS Tables for Program Allocation show that our administrative costs run at about 10% of our total allocation. We deem this reasonable given the number of programs that we run within the HiSTEM umbrella and the amount of research dollars, and hence undergraduate research opportunities, that are leveraged by the HSGC. Marcia Rei Sistoso trains our two admin student staff to handle many tasks, which would otherwise have to be managed by more expensive administrative officers. Jeff Taylor and Luke Flynn are supported at a 50%

level by State of Hawai'i matching funds and leverage research dollars from other grants to accomplish coincident HSGC objectives.

In terms of our total Program Allocation across program elements, our CMIS summary can be a bit misleading. We allot an anemic 0.8% of our Space Grant NASA funds for research. *ALL* of these funds are used to *catalyze* other research projects having an educational component that will benefit the HSGC (See section IV.3). Our Total Program Allocation table showing NASA and matching funds shows that our research allocation is a healthy 20% of our program budget, mainly due to the great success of our faculty to attract research dollars. The total dollars allotted to our Precollege program is 37% of our budget, but only 17% of our NASA Space Grant budget. The three reasons for this difference are (1) private company contributions that we receive for precollege programs, (2) participant registration fees, and (3) matching funds generated by teachers who volunteer much of their time for FFH projects; thus, our Precollege program is very highly leveraged to benefit the HSGC. Other categories including Fellowships, Higher Education, General Public, and Admin Costs are equally balanced to round out the program.

Consortium Structure/Network (Internal) Table 2 summarizes our affiliates with UH-Manoa taking the lead. Affiliates vary in effectiveness with some (Windward, Honolulu, and Maui) being very active and engaged, while others show much potential from new associate director assignments (Leeward, UH-Hilo). Our affiliates give the HSGC a very strong science and research base. Jeff Taylor, B. Ray Hawke, Ed Scott, and almost all of the community college associate directors have an interest in astronomy and planetary science. Luke Flynn and Sun Park are interested in environmental science including volcanology and remote sensing. Carlos Coimbra and Arthur Kimura are primarily interested in engineering and technology. Mark Lander specializes in meteorology. This breadth gives the HSGC at least two advantages: (1) undergraduate fellowship students can choose from very diverse NASA-related research topics, and (2) the diversity of HSGC faculty is important for establishing large joint research projects either with private industry or other university faculty.

Table 2 shows that the HSGC advisory board is as diverse as the student population with 38% being ethnic minorities. About 12.5% of our governing board are women, but Mrs. Rene Kimura and Mrs. Linda Martel also are responsible for K-12 programs, web site management, and bi-annual fellowship reviews and so have a very active role in the HSGC. The top-notch HSGC staff is chosen for their merit and enthusiasm for education. We have a very mutually supportive staff but would be happy to diversify as opportunities arise.

The HSGC staff communicates very effectively with each other as well as their student constituents. Associate Director meetings occur twice a year. We include in our meetings our K-12 program developers, because it helps all of us to understand how HiSTEM works and how each part fits into the overall program. Thus, we have open communication both vertically and horizontally within the HiSTEM program sponsored by the HSGC. Our methods of communicating with students are different depending on grade level. At the K-12 level, we have fliers posted at schools, mailings to previous participants, and updates on our Internet site (<http://www.spacegrant.hawaii.edu>). Teachers who have completed preservice or inservice courses serve as excellent spokespersons for our programs. At the University level, we again rely on campus postings for fellowship and traineeship offers, as well as the Internet. Most community college affiliates recruit HSGC trainees from their classes. Within the College of Engineering at UH-Manoa, undergraduate students select CubeSat participants and faculty mentors spread the word about HSGC-sponsored programs.

Coordination between affiliates is outstanding. For example, our community college representatives are working on an advanced CanSat that would have Windward CC developing the rocket launch facilities, Leeward, Maui, and Kapiolani CC providing the engineering support, and Honolulu CC providing data analysis. All of our community college affiliates would like to put together an online astrobiology course and a standardized astronomy lab course using HSGC observatory resources. The HSGC as a whole is working on a large NSF Engineering Research Center grant that would focus on satellite building.

Our policy has been to add affiliates as faculty members express interest in the program with the exception of the University of Guam that was placed under our umbrella by NASA Headquarters. We have a more difficult time maintaining some relationships with our community colleges because of the workload on the instructors. We have not had to drop an affiliate. We had hoped to add Hawai'i Pacific College as an affiliate but had to drop them for practical reasons. Dr. Jake Hudson, who was going to be our Associate Director there, moved on to Windward CC. Our former University of Hawai'i President Dobelle suggested that we should add all Hawai'i private universities and colleges to Space Grant at one time in order to provide equal opportunity. We are not in a financial position to do that at this time.

Collaborations and Partnerships Outside the Consortium We maintain a large number of working partnerships with other Space Grants, NASA Centers (Section III.3), and private industry. Jeff Taylor and Richard Devon (Pennsylvania SG) had combined educational forces to develop a series of on-line airborne remote sensing instructional modules for NASA Dryden's airborne program. Later, Luke Flynn and Barbara Grabowski (Penn State) took over the program and created WELES (Web Enhanced Learning Environment Strategies) which was an Internet search engine and interface designed to allow teachers easy access to remote sensing data on categorized subjects. Kaams (Kids as Airborne Mission Scientists) was a much larger second collaboration in which over 30 teaching modules and lesson plans were developed for intermediate school science teachers to be able to use in their classrooms. Kaams covered volcanic eruptions and coral reef health as science topics and won an Eisenhower education award in 2003. Jeff Taylor and Scott Hughes (Idaho SG) also started GeoSTAC which is an online series of short courses designed to pool talent from a wide range of remote sensing and geology experts for industry collaboration and workforce development. Our GG 460 remote sensing course is being put online to provide initial learning modules for GeoSTAC. We have interacted with nearly all of the NASA Centers. See section III.3 for a complete listing that is not repeated here.

We have also developed very fruitful connections with local businesses. Through our workforce development program, we have polled local high tech businesses to determine their workforce needs. Currently, we are working with two companies (NovaSol and STI) to start internship and apprenticeship programs. Interns would be undergraduate students who would receive a Space Grant fellowship of \$3000 to work on a high tech project at the company. Successful students would then be employed by the company as interns at the company's expense. Apprenticeships would be offered to Master's degree candidates at the University of Hawai'i at Manoa who would work on a company-related project and have a thesis committee consisting of UH faculty and industry technicians. We have also garnered support both in terms of monetary and manpower support from the Hawai'ian Electric Company and American Savings Bank for our Lacy Veach and Ellison Onizuka Science Days. The FIRST Robotics Program high schools ally themselves with Hawai'i high tech engineers who volunteer to help construct robots for competitions.

In terms of government agencies, we interact with the Hawai'i Department of Education (HDOE) to organize weekend Space Conferences. We also regularly interact with the HDOE to explain new HiSTEM programs and ask for permission to advertise opportunities in the Hawai'i Public School System. The HSGC has also worked with the state's Department of Business and Economic Development and Tourism (DBEDT) to issue joint proposals to NASA as well as host the high tech Universities Space Systems Symposium which brings together aerospace engineering students from the US and Japan.

Impact/Results

The operational philosophy of the HSGC is summed up by FACE the Future (Facilitate, Administer, Catalyze, and Educate). This change came in response to growing demands to participate in educational projects with affiliates and K-12 schools. Our 3-person executive committee is an integral part of our new philosophy in that it literally allows us to interact with 3 times as many projects as one person can. Weekly meetings are useful to deliberate policy and report on each of our subject areas. Facilitating and Catalyzing projects allows us to *guide* projects towards Space Grant objectives without encumbering all of the administrative or financial responsibilities. It will allow our HiSTEM program to grow in response to increasing demand for high tech education by leveraging limited resources in terms of manpower and funds. The HSGC Advisory Board is an active and vibrant group with great ideas and a sense of camaraderie that makes the planning of joint projects very easy. Adding engineering faculty formally to our board has synergized our HiSTEM engineering pipeline and allowed us the needs of local industry more efficiently.

IV.2 Fellowship/Scholarship Program

Description

Our primary objective is to enhance the education of undergraduates through active research experiences in space science, remote sensing, aerospace technology, and other fields that are related to NASA's goals. We work with faculty mentors and industry researchers to promote the value of undergraduate space and aeronautics research, especially in interdisciplinary programs. We also aim to increase the understanding and development of space and to inspire and motivate students to pursue careers in science, education and technology by educating pre-service teachers and the general public.

Almost a quarter of our NASA Space Grant funding goes to the Fellowship Program, but that works out to be about 10% of the total program allocation which includes matching funds. At UH Manoa and UH Hilo we offer fellowships for undergraduate students with a declared major who are able to spend 10-15 hours/week on their projects. Fellowships provide a stipend of \$3000 per semester and up to \$500 for travel and supplies. For students who are able to spend 5 hours/week on their projects and may not have declared a major, we offer traineeships. These provide a stipend of \$500 per semester and up to \$250 for supplies. Both programs are highly competitive and require a faculty member or senior UH researcher to mentor the student during the semester. ***Every fellowship and traineeship that our panel awards MUST have a direct connection to NASA research objectives.*** Students in both programs participate in biannual meetings giving oral or poster presentations on their work and write progress and final reports. At the UH community colleges, students compete for traineeships that offer up to \$1000 per semester. These students also participate in the biannual Space Grant meetings and work with faculty mentors. Many students have followed their traineeships at the Community Colleges with fellowships at UH Manoa or Hilo.

Through our Workforce Development program, we are working with local businesses to provide *internships* on high tech projects. Two interns were placed with NovaSol in Honolulu last summer. The HSGC provided a \$3000 stipend for one semester of support at the start of the internship. The private company provided at least one semester of support for the intern for the next semester to match HSGC support. In the case of the summer interns, both interns worked full time for a total stipend of \$6000 split equally between the HSGC and NovaSol. Dr. Rick Holasek, Vice President of NovaSol, and Dr. Jonathan Gradie, Chief Technical Officer of STI, Inc., have expressed a need for 10 interns each and are eager to support interns for 2 or more years to maintain project coherence in their respective companies. John Pye has also been successful with starting an internship program for Maui CC students involving the Maui High Performance Computing Center, Boeing, Oceanit, Trex, and the W.M. Keck Observatory. NovaSol and STI have also committed to a Master's Apprenticeship program in which graduate students would work on company-relevant projects and have a thesis committee consisting of UH faculty and industry representatives.

Core criteria

Twice a year, applicants compete for fellowships and traineeships at UH Manoa, UH Hilo, University of Guam, and the UH community colleges by submitting a proposal on their proposed work (two pages for trainees and five pages for fellows) and a one-page resume. Each proposal is reviewed by the selection panel (consisting of the HSGC Executive Committee, Drs. Scott and Hawke, and Linda Martel), which is augmented when needed by other university faculty and senior staff. The criteria for selection are the academic qualifications of the student (a GPA >3.0 and high grades in relevant courses), the quality of the proposed work and *its relevance to NASA's goals*, and the feasibility of completion in one or two semesters. If the proposal does not have an explicit NASA connection, it is either returned for clarification or rejected. We also require a clear statement from the mentor of their willingness to supervise the student during the semester. Proposals from the University of Guam are unique in that we found teams proposing research tasks were more likely to attract student participation. The panel recommends which proposals should be funded.

During the semester the student's progress is monitored through a 2-3 page progress report and an oral presentation at an all-day meeting of fellows, mentors, and Space Grant Directors. These meetings also help the students to organize their work, make effective presentations, and learn from discussions with other students and faculty. To receive the final installment of their stipend, fellows have to submit either a 5-6 page final report or a request for a second semester's funding, which is reviewed by the selection panel. The final reports are published every year in a volume and copies are sent to fellows, mentors, other Space Grant Consortia, NASA headquarters, and libraries of the UH system. The final report provides excellent experience for students in writing a research paper.

The Hawai'i Space Grant Fellowship Program focuses extra effort to involve women, underrepresented groups and persons with disabilities. US Census Bureau statistics for the year 2000 for Hawai'i show the following percentages: 24.3% white, 1.8% black, 41.6% Asian, 9.4 % Pacific Islander or Hawai'ian, and 21.4% having two or more races, versus for the US overall 75.1% white, 12.3% black, 3.6% Asian, 0.1% Pacific Islander, 2.4% more than one race. Ten percent of our fellowship awards go to the underrepresented which accurately reflects the Pacific Islander and black population in Hawai'i. If we were to add in Asian fellowships, our underrepresented numbers would increase dramatically. About 32% of our fellowships went to women, which is slightly less than the 49.8% female population in

our State. We recruit students with posters that are distributed over all campuses twice per year. In addition, we work to recruit underrepresented groups through specific school interaction with our precollege program in order to generate interest in HiSTEM early. In addition we write a letter every 1-2 years to all UH faculty in technical and scientific fields explaining the fellowship and traineeship programs, inviting them to participate by mentoring students and asking them to complete questionnaires that can be used by students looking for mentors. Our website, which is frequently updated with news of fellows' achievements, provides full details about the fellowship and traineeship programs and application forms.

Impact/results

Our Fellowship program is very strong owing to the dedication of the mentors and the breadth and quality of research projects available for undergraduates to undertake. In the last 5 years, we have had fellows pursue research in planetary science, astronomy, remote sensing, environmental studies, physics, biophysical studies, electrical engineering, and mechanical engineering. We have not concentrated on providing Space Grant funds for graduate students because HIGP faculty hire them for their research projects. We have found it more difficult to engage students at the community colleges with research fellowships than the 4-year universities. For this reason, we started the traineeship program to ease students into more demanding fellowship projects. Added to this next year will be a CanSat program at each of the community colleges that will allow students to do engineering projects designed to fly at high altitude and be recovered.

We judge our fellowship programs on the number of applications received, the quality of the student projects proposed, the percentage of students successfully completing their research (>90%), the quality of their presentations at the semiannual undergraduate research symposiums, the quality of their final reports, and the general enthusiasm of students, mentors, and university administrators for the programs. CMIS Tables show that all of our affiliate campuses have received fellowship support within the last 5 years.

The standard of research performed by fellows is high according to our criteria. We are particularly pleased at the number of engineering students who have successfully completed their fellowships and made presentations at national meetings. During 2001-2005, over ten fellows in the UH Manoa Engineering Department have been involved in the UH CubeSat program that successfully built a small satellite. Three fellowship students in the last 5 years have won national recognition with the Alton B. Zerby and Carl T. Koerner Outstanding Electrical Engineering Student award as well as the Engineering Student of the Year in Hawai'i. This success has allowed our engineering *undergraduates* to win a \$100,000 grant for students to build a nano-satellite. These accomplishments have also generated interest from local companies to hire students as interns. We have not kept track of all of our Space Grant Fellows after graduation, but as an example, of Dr. Wayne Shiroma's 15 Fellows, 1 has obtained a PhD and 9 have gone on to receive or enroll in advanced degree programs.

IV.3 Research Infrastructure Program

Description

UH Manoa is a thriving research institution, especially in the sciences. The Institute for Astronomy (IFA) and the School of Ocean and Earth Sciences and Technology (SOEST), the two units most concerned with space science, are world-renowned and bring in \$70 million in research grants every year. The Hawai'i Institute of Geophysics and Planetology, which is part of SOEST and is the parent organization for Space Grant, is awarded almost \$10 million

in grants a year. Consequently, we have not emphasized development of our research infrastructure because it is already strong. Nevertheless, the Space Grant program has given us some opportunities we would not have had, and it has helped promote research at UH Hilo and the Community Colleges.

Our program to enhance the research infrastructure of the consortium uses a mix that includes the undergraduate fellowship program, targeted research opportunities, and development of large research programs. We also have a unique research program in that past director Jeff Taylor's tenured position was created as part of the state's matching funds for Space Grant. This was established as a research faculty position so much of Taylor's efforts must be devoted to research. Counting the matching funds, on average about 20% of our budget is devoted to developing and maintaining the research infrastructure of the HSGC (not including the Fellowship program); almost all funds are from state resources.

Role of the Fellowship Program. The Undergraduate Fellowship program, described in the previous section, has contributed to the research productivity of our faculty mentors. Although designed to train and inspire students, the research programs of faculty mentors benefit from student participation. The students contribute genuine new data and ideas to the research with which they are involved. For example, continued research and innovation on the design and construction of active struts and surfaces (useful on satellites and aircraft for stability) has benefited from a series of undergraduate fellows working with Dr. Mehrdad Ghasemi Nejhad in Mechanical Engineering at UH Manoa. This experience is leading Nejhad to develop plans to obtain NASA technology funding. The fellowship program also funded our initial efforts in building small satellites and enhanced remote sensing research at UH Hilo. *The research springing from the fellowship program helps establish new faculty (and faculty new to space science or engineering) and maintains coordination with NASA programs such as Space Science, Earth Science, and Space Technology.*

Targeted Research Opportunities. Because of strong research programs at UH Manoa and UH Hilo, we have not focused on providing seed grants to individual faculty members. Nevertheless, opportunities have arisen that allowed us to help spark new research programs. Use of Space Grant funds for research was guided by the following principles: (1) The research should be in a new or growing field that is likely to lead to future funding. (2) The research should involve undergraduate students as active participants. (3) The work must lead to a proposal to an extramural funding agency.

Using these principles, we funded an effort by Dr. Peter Mougini-Mark (Hawai'i Institute of Geophysics and Planetology) to do some initial research on Mars so he could apply to the Mars Data Analysis Program (MDAP). Space Grant funds were used to fund a computer specialist to develop programs to analyze topographic data from Mars. Although Mougini-Mark was an established Mars researcher, he had dropped out of active research on Mars to concentrate on terrestrial remote sensing. The lure of exquisite new data from Mars made him want to resume research on the geologic history of the Red Planet. The small seed grant enabled him to obtain funding from MDAP (about \$70k per year), and resulted in several publications. Unfortunately, successful proposals like this were not reported to CMIS.

We also have provided some travel support to Prof. Jeff Taylor to attend the annual meeting of the Space Resources Roundtable, an important meeting about space resource utilization, and to the 2002 World Space Congress to present papers about the use of lunar and Martian resources. As part of this effort, Taylor wrote two papers, co-authored a chapter in a forthcoming book about the Moon, and submitted a proposal to the Steckler Opportunity.

This field will increase in importance as NASA begins to look beyond Earth orbit. Considerable private money might become available and we plan to ensure that our consortium is in a position to work on the human exploration of space. It is important to understand that the Act that created the national Space Grant program places a lot of emphasis on the use of space resources. These targeted programs *help new faculty become established (or re-established) and help coordinate to other NASA programs (Space Science, Human Exploration and Development of Space).*

Research and the State's Matching Funds. As noted above, Jeff Taylor's research faculty job was created as part of the state of Hawai'i's matching funds for Space Grant. Thus, any research done by Taylor and any new research programs created by him should also be credited to Space Grant. During the past five years, he has continued his research on the Moon, asteroids, and Mars. He has become especially heavily involved in Martian research and is a member of the Mars Odyssey Gamma-Ray Spectrometer (GRS) Team. The GRS research received \$88k last year and will receive about \$125k this year. During the past five years, Taylor has published 18 peer-reviewed scientific articles, which is not accurately reflected in the CMIS Tables. (This is lower than his career norm because his stint as Space Grant Director severely cut into his research time.) His research on space resources is also funded by the state matching funds. *These research efforts show strong coordination with other NASA programs: Space Science and Human Exploration and Development of Space.*

Large Project Opportunities. The combination of Space Grant's Fellowship program, new workforce development program, our strong relations with local remote sensing companies, and our targeted improvement in research infrastructure have led to new opportunities. One of these is a major effort to study coral reefs from the International Space Station. The program began as a proposal in 2000 to NASA's Universities Earth System Science Program. The objective of the project is to conduct a global inventory of coral reef health using a high spatial resolution, multi-spectral imaging system. Space Grant's role was to coordinate all undergraduate involvement (approximately 20 students per year). There was close collaboration with two local remote sensing companies (TerraSystems and NovaSol) on this project. Our proposal was among five finalists, but then funding was diverted. It now appears that the program will be revived through the defense department, and that we will receive about \$10 M, of which Space Grant will receive \$500k for workforce development and research as part of the overall project.

Our funding and encouragement of the CubeSat program has led to a strong and growing small-satellite program in our College of Engineering. Our colleagues there are eager to build larger satellites (in the 10-kg range) and to develop an infrastructure to launch small payloads. We have a military launch facility of the island of Kaua'i (the Pacific Missile Range Facility), and officials there are interested in collaboration. There is a need for launch facilities and capabilities for small payloads. The effort to develop these capabilities is led by Carlos Coimbra, Associate Director for Aerospace Engineering.

Jeff Taylor is leading an effort to develop a mission to return samples from the South Pole-Aitken basin, on the farside of the Moon. The proposal will be submitted to NASA's New Frontiers Program. Called *Farside*, the mission will be managed by Applied Physics Laboratory, with major spacecraft systems built by Boeing and a sample-acquisition system built by MD Robotics. This mission has magnificent research and education opportunities. Wisconsin Space Grant Director Aileen Yingst is in charge of landing site selection and the large (about \$10M) Education/Public Outreach effort. This large proposal (\$650 M cost cap)

would not be possible without Space Grant support in the form of Taylor's salary and our vast experience in Education and Public Outreach.

Large project opportunities allow us to link to NASA Enterprises (Space Science, Earth Science), NASA Centers or equivalent (APL, Johnson Space Center), and develop strong ties with industry (Boeing, MD Robotics, NovaSol, STI).

Core Criteria

Many projects in our research infrastructure program incorporate collaboration or cooperation between two or more disciplines or fields of study. Examples are summarized briefly in the table below, listed by category described above. We have not included the fellowship program because of the large number of projects.

Our activities fit into the NASA strategic enterprises, except for Biological and Physical Research, as also shown in the table below.

Table3. Interdisciplinary projects funded or sparked by our research infrastructure program.

Category	Project	Enterprises	Fields
Targeted Research Opportunities	Lunar and Martian Resource Exploration, Extraction, and Use	Space Science, Human Exploration and Development of Space	Resource exploration, mineralogy, geochemistry, remote sensing, resource needs, lunar and Martian base strategies, economics, materials science, engineering.
	Coral reef conservation and management	Earth Science	Remote sensing, ecology, marine science, resource management.
State Matching Funds	Mars bulk composition and crustal evolution	Space Science	Petrology, geochemistry, aqueous alteration, astrobiology, planetary origins
Large Project Opportunities	Coral Reef Observations	Earth Science	Remote sensing, engineering (electrical and mechanical), project management, earth science.
	Small Satellite Program	Aerospace Technology, Earth Science, Space Science	Engineering (aerospace, electrical, mechanical, civil), remote sensing (payloads), project management, earth science.
	<i>Farside</i> lunar sample return mission	Space Science, Aerospace Technology	Lunar science (remote sensing and sample analysis), mission planning and management, engineering

Impact/Results

We believe that we have used our research infrastructure funds effectively. Our funds have sparked some programs that may lead to large scientific and educational enterprises.

Strengths and Weaknesses. A major strength in our program is that we have tapped into exciting intellectual resources. Perhaps the best example is our small satellite program, which sprung initially from encouraging engineering faculty to attend the Universities Space Systems Symposium. We asked one of our experienced and enthusiastic engineering mentors, Wayne Shiroma, to attend and take some students with him. We paid their travel expenses. One of the topics covered during the symposium was CubeSat, and Wayne and his students were inspired. The result is a CubeSat built and ready for launch, and a budding student satellite program here at UH. Our only serious weakness is that we have not helped as many underrepresented minorities as we would like to, although women have benefited. (We assume that Japanese and Chinese Americans are not considered underrepresented.) Part of the problem is that our faculty does not contain a high percentage of minorities in science

and engineering. We did have minority students participating in the CubeSat project (at least two of which were Native Hawai'ians and graduates of Kamehameha Schools).

Maintenance of Research Capabilities. Our program over the years has helped maintain space-oriented research at UH Hilo. For example, we helped UH Hilo Asst. Professor Barbara Gibson through summer salary support and by supporting an undergraduate fellow. Ms. Lisa Wedding, a senior in Marine Science, mapped and classified coral reefs using color infrared aerial photographs and GIS software. The results of this work will benefit conservation and management of coral reef ecosystems in Hawai'i. Dr. Gibson is working with Ms. Wedding on a paper stemming from this research. Even at the large, research-oriented Manoa campus our seed money has helped maintain space science.

Metrics to Demonstrate Success. The metrics we use to judge success differ with each project. In the case of funding research that is intended to lead to a successful proposal (i.e., Pete Mouginis-Mark's Mars research). In the case of CubeSat we wanted (1) wide participation and (2) a satellite ready to launch. Both criteria were met. Over 50 students and eight faculty members participated in the project, which is ready to launch. Even the hassle of finding suitable launch opportunities (shared with the other Space Grant sponsored CubeSats) is not a failure as it helped bolster our enthusiasm for developing a launch capability here in Hawai'i. The large projects are almost never failures in that we help to assemble a team to pursue a goal. For example, the original coral reef project brought together researchers from HIGP, the Departments of Oceanography, Biology, and Computer Science, and local industry. This same team can pursue the project through other sources.

IV.4 Higher Education Program

Description

Purpose, Goals, and Objectives. The overall goal of the HSGC is to provide opportunities for high technology education for the people of Hawai'i in order to fill the demands for the next generation of NASA engineers and technicians. After the tragedy of 9-11, the demand in Hawai'i for highly skilled engineers and technical staff has grown tremendously. The HSGC authored a successful workforce development proposal which outlined a Master Plan for university, industry, and government interaction here in Hawai'i. Those funds have been used to foster closer ties to local industry and promote high tech applications within the College of Engineering. Our higher education program is multi-faceted and has grown tremendously in the previous year as a result of increased collaborations with other University schools (Engineering and the Institute for Astronomy in particular), private industry, and government agencies. Our objective is to expand our vertically-integrated HiSTEM program to not only enrich the learning experience but also provide more pathways for entry into highly technical fields of study. A portion of our higher education program has already been described in the Fellowship/Scholarship Program (Section 2).

Workforce Development. Last year, the HSGC responded to NASA's renewed call for greater interaction with high-tech industry and government agencies to provide training for a high tech workforce. Dr. Rick Holasek, Vice President of NovaSol, Inc. in Hawai'i estimated 30 months ago that his company would need 20-30 Master's and PhD level technicians within 3 years. NovaSol has already met that by filling 20 new high tech positions in 2.5 years. To meet this demand, the HSGC developed a Master Plan for workforce development to be accomplished in three stages. Stage 1 initially includes providing three levels of educational outreach and training along three separate technical tracks. Stage 2 focuses on

University/government/corporate sector joint proposals. Stage 3 of the plan results from stage 2 as specialized courses and teaching personnel within the University are added.

In terms of educational outreach and training (Stage 1), we have been in contact with Dr. Scott Hughes (Idaho State) to develop the GeoSTAC program which is a series of short technological bursts of information focusing on specific problems that can best be delivered in short week-long courses or the focus of on-line web courses. A Space Grant-wide effort from many Consortia could create a pool of talent to expedite the passage of NASA technology into the work force. We have organized courses to provide some overlap for basic introductory remote sensing and GIS courses and more in-depth follow-on courses at the UH-Manoa campus. Joe Ciotti at Windward Community College has a GIS course that will serve as the introduction to a follow-on course (GG 711: Advanced GPS/GIS Techniques by Drs. Scott Rowland and Mark Davies) being developed through funds provided by this program. The University of Hawai'i-Hilo also has a GIS course that they have developed and sponsor a remote sensing course (Natural Sciences 474: Remote Sensing for Teachers) that introduces teachers to the latest developments in NASA technology. These courses currently feed into a more detailed lab-based computer course (GG 460: Geological Remote Sensing) that features applications of many NASA data sets.

In terms of joint research proposals (Stage 2), the HSGC undergraduate research program will benefit from a \$500,000 (first year) proposed effort to study the world's coral reefs and volcanoes using instruments on the International Space Station. In terms of course and curriculum changes (Stage 3), we have received an offer from NovaSol to have industry representatives interact with the Geology and Geophysics as well as the College of Engineering curriculum committees.

Hawai'i Small Satellite Program. Our interactions with the College of Engineering have created many research opportunities for undergraduates. The centerpiece of this is the CubeSat small satellite program started here in 2001. CubeSat is partially sponsored by HSGC workforce development funds. The purpose of the program is to design, build, test, and launch a small (10 cm x 10 cm x 15 cm) satellite into space by 2005. This remarkable program is mentored by Drs. Carlos Coimbra (Mechanical Engineering, Associate Director) and Wayne Shiroma (Electrical Engineering), and is driven by undergraduate engineering students. Fifty-four students formed 6 design teams to work on the project. This is a challenging project that will require careful organization, project management, and fund raising. The students were successful in obtaining a \$100,000 NASA/Air Force grant to build a similar Nanosat satellite. CubeSat Project Director Aaron Ohta won the 2003 Alton B. Zerby and Carl T. Koerner Outstanding Electrical Engineering Student Award. As a result of CubeSat success, the HSGC will sponsor related CanSat projects at the Community Colleges. The first successful CanSat launch took place in early 2005 at the Honolulu Community College. Kapiolani Community College also attempted a launch later in the spring, but lost their balloon to high trade winds. Nevertheless, the CanSat program has brought together 5 community college campuses and their students to design and build atmospheric experiments to be lofted on balloons or large rockets.

Undergraduate Courses and Teacher Training. The HSGC has sponsored 13 undergraduate and graduate level courses in the last 5 years as summarized in Table 4. Four of these courses were targeted for teacher training (pre-service and in-service). Most of these courses focus on placing an emphasis on remote sensing/GIS techniques within traditional geology

and geophysics courses. Others such as GIS 150 and GG 711 (Applied Field Methods) are designed as complementary follow-on courses within our HiSTEM program.

Table 4. Higher education courses offered through the HSGC.

COURSE NUMBER	CAMPUS	COURSE TITLE	Years Offered
Natural Science 494	UH Hilo	Space Education for the Elementary and Middle School Classroom - Kimura	1999-2002
Elementary Ed. 472	UH Hilo	Elementary Science Methods - Kimura	2000
GG 101	UH Manoa	The Dynamic Earth - Taylor	1998
GG 168	UH Manoa	Planetary Science in the Classroom – Taylor	2000
GG 305	UH Manoa	Geological Field Methods - Rowland	1998-1999
GG 460	UH Manoa	Geological Remote Sensing – Rowland, Flynn, Wright	1998-2003
GG 593	UH Manoa	Mission to the Red Planet – Kimura	1999-2003
GG 610	UH Manoa	Theoretical Petrology - Taylor	1999
GG 611	UH Manoa	Accelerated Intro to Geology - Taylor	1998-2002
GG 673C	UH Manoa	Petrologic Evolution of the Moon - Taylor	1998-1999
GG 711	UH Manoa	Seminar: Bulk Composition of the Terrestrial Planets - Taylor	2001
GG 711	UH Manoa	Applied Field Methods Merging GPS and GIS Techniques (Workforce Development) – Rowland Davies	2002
GIS 150	Windward CC	Geographic Information Systems - Ciotti	1998-2001

Undergraduate Research at the Community Colleges. Astronomical observatories on the Big Island have created an interest in extra-terrestrial exploration among Hawai'i students. A 20-inch telescope is now fully operational at Leeward Community College. The facility provides excellent opportunities for undergraduate astronomy laboratories and undergraduate research by Space Grant fellows. We also purchased (with state funds) a 10-inch telescope for use by students at Kapi'olani Community College. Dr. John Rand has developed astronomy laboratories and undergraduate research projects that make good use of the telescope. Dr. John Pye has started to marshal the Community Colleges to develop a standardized Astronomy 101 Lab Course through HSGC affiliations.

Dr. Joe Ciotti of Windward Community College has been especially successful with expanding educational opportunities for Hawai'i students. He has recently received funding to expand the Center for Aerospace Education. The facility now includes the Aerospace Exploration Lab (a hands-on science exploratorium), the Hokulani Imaginarium (a planetarium and multi-media theatre), the Lanihuli Observatory (radio and optical astronomy and meteorology), and the NASA Flight Training Aerospace Education Lab (flight simulators). We are hoping to use these facilities to prompt a new set of student projects.

Support of Space Grant Education Priorities. The HSGC fully supports the 7 Space Grant Educational Priorities as outlined in the 1996-2000 strategic plan. In this section, we will indicate relevance based on the undergraduate education program. (1) *Engineering partnerships* - As elaborated above, we have integrated engineering with our geoscience and planetary science objectives. We are also working with industry to facilitate engineering internships. (2) *Undergraduate training* – We offer a wide range of courses (Table 4) as well as NASA-related fellowships, traineeships, and small satellite building opportunities. (3)

Interdisciplinary and introductory courses – GG 101, 168, and GIS 150 are introductory and interdisciplinary courses designed to pique student interest in high tech careers. (4) *Preservice education* – GG 168, 593, NS 494, and Elem. Ed. 472 are all directed at preservice education to help teachers develop high tech lesson plans. (5) *Community college interaction* – Our affiliates fully participate in our research traineeship programs as well as provide courses for HiSTEM (Table 4: GIS 150). We will increase their interaction with the high tech CanSat program. (6) *Women and Minority Participation* - See section below. (7) *Instructional technology and tech transfer* - We offer courses through GeoSTAC and traditional courses (GG 460, GG 711) that teach current techniques and are held late in the afternoon to encourage industry/government participation. We co-propose research efforts (space station coral reef project) involving technology transfer to private companies.

Strategy for Recruitment of Women, Underrepresented Minorities, and Persons with Disabilities. The University of Hawai'i is a minority institution comprised of mainly Native Hawai'ian, other Pacific Islander, and Asian students. See Diversity section III.1 for more details. We specifically work towards recruiting women into our programs and have had good representation in the CubeSat program as well as in our undergraduate courses. We anticipate that this trend will continue as we have focused efforts in at K-12 in our HiSTEM pipeline for the recruitment of women.

Core Criteria

The HSGC Higher Education Program places a *heavy emphasis on undergraduate education* that relies on both practical courses (Table 4) as well as hands-on high tech projects (CubeSat, NanoSat). A mix of the two is necessary to provide the fundamental framework for high tech education and research as well as practical training experience.

The HSGC program *incorporates collaboration and cooperation between two or more fields of study or disciplines*. The HSGC is based in the Hawai'i Institute of Geophysics and Planetology; hence, many of our courses were geoscience related (Table 4). However, most of our affiliates balance this with a strong Astronomy perspective. In the last year, our partnerships with the College of Engineering have grown through the small satellite program administered by HSGC Associate Director Carlos Coimbra and Wayne Shiroma. Faculty at HIGP and Engineering are now working on a joint proposal to develop small satellites for an NSF Engineering Research Center grant. HSGC *facilitated* this communication.

Impact/Results

The HSGC Higher Education Program plays a culminating role within the HiSTEM program. It engages undergraduate students with high technology courses and research opportunities that are designed around hands-on experiences.

Strengths and Weaknesses of the Program. With experience, we have built an extremely successful program of course offerings and hands-on research opportunities. The three shining successes of our program are the integrated HiSTEM program, the small satellite program, and course integration. Our HiSTEM program is very comprehensive and vertically integrated, offering many opportunities at K-16 to enter one of three high tech pipelines. Each stage of education offers many exciting interactive research opportunities that readily build into other programs along the pipeline. The UH small satellite program has already garnered many awards and much interest for its student engineers. Undergraduates were able to attract their own \$100,000 grant to support the program and CubeSat will be the basis for many other proposal opportunities (NSF – Eng. Research Center) in the coming year. We have begun to link together course offerings between the Community Colleges and

UH-Manoa campus (GIS offerings) and between Community Colleges (planned Astrobiology and Astronomy Lab courses). Our weakness is that our community college affiliate participation is highly variable but has increased recently. We intend to develop a CanSat program within each college to encourage student participation in high tech research.

External Metrics – The HSGC continues its commitment to provide new courses that reflect NASA's cutting edge technical advances (Table 4). The workforce development program is pulling together UH researchers, students, and industry technicians to develop new curricula, enhance existing courses by emphasizing relevant skill sets, and pool talent to create winning proposals that benefit all. Our GG 460 course has been full for 5 years and is the most well-attended GG course above the 101 level and serves government and industry personnel. Our teacher preparation courses and FFH stress NASA technology and continue to draw great interest from teachers as measured by attendance.

IV.5 Precollege Education Program

Description

Purpose, Goals, and Objectives. The main objective of the pre-college program is to attract as many students as possible to the HiSTEM pipelines by stimulating interest in NASA activities and high technology fields. A key component is the education and re-education of classroom teachers who can then pass on NASA-related lesson plans to their classes. Our pre-college program is directed in large part by former classroom teachers Mr. Arthur Kimura, Director of the FFH program, and Mrs. Rene Kimura, HSGC educational specialist. The precollege program has enjoyed great success (CMIS participants = 10,792 average) using the FFH model of hands-on, interactive, module-based learning. The HSGC now offers 2 astronaut appreciation days as well as Family Science Nights that are based on the same teaching style.

Future Flight Hawai'i(FFH) – FFH is a space-themed educational program designed to catalyze a child's interest in science, technology, and the future. Using a mission format, the participants experience a variety of training modules to prepare them for their simulated missions to extra-terrestrial sites. FFH is the hub of all of our K-12 activities and the anchor of the HiSTEM pipeline to high tech careers. It celebrated its fourteenth anniversary in 2005 and continues to be fantastically effective. In 2005, the weekend, day, and residential programs were attended by over 200 students and parents. About 35 teachers also benefited from the experience. Part of FFH's activities is a series of Space Conferences held on weekends during the school year which include teams consisting of a student (grades 5-8), his or her parent, and his or her teacher. Many new FFH hands-on modules are tested during the Space Conferences. The Conferences are a collaboration between the HSGC and the Hawai'i Department of Education, which receives funds from the state legislature for the project. FFH staffed a booth at the 2002 annual meeting of the National Science Teachers Association. All activities demonstrated are available online through the HSGC web site.

FIRST: For Inspiration and Recognition of Science and Technology – The FIRST Robotics Competition is a national engineering contest which immerses high school students in a high tech engineering project. Teaming up with engineers from businesses and universities, in six intense weeks, students and engineers work together to brainstorm, design, construct, and test a robot. Each team travels to the Mainland to compete their robot against others. FIRST started in 2000 with 2 high school teams of which 32% of the team members were women. Last year's program included 6 high schools and an astounding 76% women

team members! About 90% involved in the project belong to underrepresented groups. Soon, we may have enough schools to have a Hawai'i competition. The HSGC provides support for teams to compete (8 airfares last year to Waikeke (3), Wai'alu (2), McKinley (1), and Waipahu (2) High Schools). Wai'alu, Waipahu, and McKinley won awards at the competitions. The HSGC was recognized for its contributions in citations from the state legislature and the Honolulu City Council. We continue to support this valuable activity.

Botball For the past two years, the HSGC, Hawaiian Electric Company, and the Hawaii Convention Center have combined with the KISS Institute for Robotics to offer the Botball program. Botball has been highly successful and culminates with a team-based competition held at the Hawaii Convention Center in the spring. Each Botball team is tasked to build and program a robot in the C++ programming language. The robot must complete a certain number of tasks on a given course in 90 seconds. The robot has to be entirely pre-programmed prior to the competition.

Family Science Nights, Classroom Visits, Astronaut Appreciation Days The FFH program has been very successful and has launched a number of spin-offs using a similar instructional format. Our challenge was to reach more students and parents. Family Science Nights provide space science activities for students, parents and teachers in an evening session. The objective of the program is to increase participation and interaction of families in student learning through hands-on science and, hence, attract more students to the HiSTEM program. FFH Family Science Nights have been tremendously successful, reaching about 2000 students, parents, and teachers per year. In addition, the FFH staff continue to sponsor "Living in Weightlessness" classroom visits which reach a further 4000 students and 200 teachers per year. Moreover, the FFH staff along with monetary support from American Savings Bank (\$15,000 annually) and Hawai'i Electric Company (\$20,000) support the Ellison Onizuka and Lacy Veach Days of Discovery, which each cater to 600 students and their parents. The Ellison Onizuka Day is held in January in Hilo on the UH-Hilo campus and provides an opportunity for hands-on learning with distinguished NASA-allied speakers opening and closing the daylong high tech workshop. The Lacy Veach Day is held in November in Honolulu. Both Days commemorate Hawai'i's late astronauts.

Education for the Elementary School Classroom Art and Rene Kimura also teach a UH Hilo undergraduate course for teachers, which has been very successful. The HSGC-sponsored course was taught again in 2005 with UH-Hilo serving as the venue. It focuses on methodology, with excellent space science and engineering content a side benefit. The course is taught during the school year, and requires teachers to try out the inquiry-based activities given them. This ensures that the teachers will use the materials in their classes. Under a separate grant from NASA's Education Office, Luke Flynn and Scott Rowland taught NS 494 (Table 4) for two years as Remote Sensing for Teachers. Teachers had to develop and execute classroom lessons using a GPS, GIS software, and a mini spectrometer. LUAU I and II were projects completed with the Pennsylvania SG and NASA Dryden. Both projects involved development and organization of online remote sensing materials to help teachers form lesson plans involving the study of coral reef health and volcanic eruptions.

Office of Space Science/ Broker Facilitator Program We joined with the Space Science Network Northwest (S2N2) to participate in the Office of Space Science's Broker/Facilitator program. This program includes SG Programs in Washington, Oregon, Idaho, Montana, Wyoming, Alaska, and Hawai'i. Mary Ann Kadooka serves as the Hawai'i point-of-contact for the educational, professional science, and public constituencies in the region to build

understanding, connections, and participation in OSS missions and NASA activities. We have almost completed creation of a database that organizes the names and specialties of scientists with space science interests. We will begin on an analogous database for educators.

Support of Space Grant Education Priorities. The 1996-2000 Strategic Plan includes directives for undergraduate education. We address those seven priorities in section IV.5 above. Our integrated HiSTEM program provides for high tech educational experiences at the Precollege and Higher Education levels. The FFH program starts students on the high tech pathway early and includes hands-on engineering modules such as building solar cars and operating robots. The highly popular FIRST Robotics Program for high school students continues our commitment to encouraging students to pursue engineering careers. We have a very strong program for pre- and inservice teacher education which includes courses listed in Table 4 (UH-Hilo: NS 494, Elem. Ed. 472; UH-Manoa: GG 168, GG 593). In addition to these courses, we offer teacher training through the FFH program that includes teacher participation at the summer programs, Family Science Nights, and classroom visits.

Strategy for Recruitment of Women, Underrepresented Minorities, and Persons with Disabilities. The University of Hawai'i is a minority institution comprised of mainly Native Hawai'ian, other Pacific Islander, and Asian students. We encourage participation of women, underrepresented minorities, and persons with disabilities in all aspects of our program. FFH Program Director Arthur Kimura was able to attract a Women and Technology grant in the amount of \$50,000 (and advises spending of a further \$75,000) which supports the participation of women high school students in a variety of high tech programs. This includes sponsorship of a largely women engineering team for the FIRST robotics program at Waiakea High School on the Big Island of Hawai'i. For the past three years we sponsored four high schools (Waieka, Waipahu, Waialea and McKinley) because of a large population of underrepresented student body. Female participation in this program had increased tremendously for the past three years to 76% last year. For four years we provided extensive hands-on science activities at the annual GEMS (Girls Engaged in Math and Science) conference. There were 708 females of which 44% were underrepresented minority students. In 1998, we sponsored a Multi-Sensory Teachers' Workshop. The purpose of this workshop was to train teachers in the use of a kit of materials for use in classes for the learning disabled. The kit was developed with NASA funding. Our HSGC web site is fully 508-compliant meaning that it can be accessed by blind individuals. Our HSGC offices are all wheelchair accessible as are the classrooms at which our courses are taught.

Core Criteria

The FFH program was originally developed through the Hawai'i Department of Education and was designed to *align with state science and mathematics education standards*. Art and Rene Kimura, developers of the FFH program, as former DOE teachers are keenly aware of DOE science and mathematics objectives and stay current with state education policy by maintaining close links with DOE officials.

Our HiSTEM program places an emphasis on teacher preparation and development. We have a very strong program for pre- and inservice teacher education which includes courses listed in Table 4 (UH-Hilo: NS 494, Elem. Ed. 472; UH-Manoa: GG 168, GG 593). In addition to these courses, we offer teacher training through the FFH program that includes teacher participation at the summer programs, Family Science Nights, and classroom visits.

Impact/Results

Our precollege program has had a very big impact in the State of Hawai'i in terms of support from a populace interested in high tech education willing to allocate resources to start new projects. Numbers of participants are telling metrics. The FFH program and spin-off events such as the Lacy Veach Day of Discovery and the Ellison Onizuka Science Day attract over 1000 students per year and sell out well-before the registration deadline. The Family Science Nights serve over 2000 students, parents, and teachers per year. The popularity of the FFH program is well established. The FIRST Robotics Program has grown to 6 high schools at which teams have to turn away potential participants because the program attracts too many students. In a State suffering from a shrinking economy due to waning tourism, we have taken it upon ourselves to provide science educational support and worked in depth with 15 schools to enrich their curriculum by including space science to enrich science, math, and reading. Notable successes are our partnerships with non-traditional educational supporters that have kept programs afloat. The American Savings Bank in Hawai'i helped to sponsor the Ellison Onizuka Science Day in Hilo, while the Hawai'ian Electric Company donated funds and numerous interesting high tech exhibits to the Lacy Veach Day of Discovery on Oahu.

Although the FIRST Robotics Program is working well at the high school level, there is a definite gap in our program at Grade 9-12. We are aware of this and are working to expand our program at this level. We had conversations with Kamehameha Schools, an underrepresented student body (Native Hawaiians) to provide new science curriculum for their Big Island and Maui. These efforts have resulted in scheduled Family Science Nights. A second weakness concerns ramping up precollege programs to meet very high demand. Unfortunately, this will require more HSGC funding to hire more educational specialists.

In addition to participant numbers, we have two other external metrics that help us to determine the success of our programs in the State of Hawai'i. (1) Number of participants entering high tech careers – FFH celebrated its 11th birthday in 2002. Some of its former students have already gone on to advanced degrees or to high tech jobs. (2) Curriculum development – FFH modules and Space Conference lessons are used to modify the existing curricula. Programs such as LUAU were developed to provide teachers with a much more detailed view of mission planning and execution from the point of developing the flight plan to reducing the data gathered.

IV.6 Public Service Program: General Public and External Relations

Description

Purpose, Goals, and Objectives. Our public service program is highly successful (CMIS report of 31,501 participants on average) and is synergistic with our other program elements. There is a close interplay of our Precollege Education Program with our activities to engage the general public. For example, our Family Science Nights involve students and their parents. Similarly, our external relations activities with local industry focus on workforce development, so involve the Fellowship program, higher education, and research infrastructure. We will emphasize public outreach only in this section. Our public outreach efforts are geared to engaging the public in the utility of space exploration. About 10% of our total budget (NASA plus matching funds) is devoted to this effort. Our philosophy is to engage the public. The term 'public engagement' is more appropriate than public outreach. We need to *involve* the public, not merely tell them interesting things about space science, earth science, and aerospace engineering. We want our program to grab the public at some

visceral level. We intend to address the entire issue of how we engage the public through our own programs and through our work on proposals for missions.

Main Programs. One of our strongest efforts in public outreach is our publication of *Planetary Science Research Discoveries (PSRD)*, an online magazine in which planetary scientists share their discoveries and thus seize the attention of teachers, students, and the public. The HSGC publishes the magazine with funding from Space Grant (in the form of a portion of Jeff Taylor's salary) and NASA's Cosmochemistry Program (Office of Space Science). The site is edited and managed by Jeff Taylor and Linda Martel. We believe that the research is not done until it has been communicated—in plain language—to the public. Hence the magazine's motto: "Planetary scientists sharing ideas and discoveries." The Cosmochemistry Program awards \$65k/year to Taylor for this project. For the curious, find the site at www.psrld.hawaii.edu. We publish about an article per month.

Space Grant played an integral role in planning and producing a major exhibit at the Bishop Museum: Scientists in Hawai'i are doing exciting exploration from the sea to the stars, and we can understand and be inspired by their research when we get to know the people who are doing it. The exhibit emphasized the researchers and their work. Specific themes were the ocean floor, Loihi (an undersea volcano), oceans and atmosphere, reefs and beaches, Kilauea, astronomy from Mauna Kea, and planetary exploration (moon, asteroids, comets, Mars, icy satellites, search for life in the universe). The exhibit opened January 27, 2001 and closed May 18, 2001 (half the exhibit remained open through July, 2001). More than 100,000 people viewed highly popular the exhibit during its four-month run. Most important, the project formed a true partnership between the Bishop Museum and the HSGC.

We reached thousands of people for several years by sponsoring broadcast of StarDate, an astronomy show produced by McDonald Observatory. Budget priorities have caused us to cancel our sponsorship. Members of our consortium also give numerous public lectures and give interviews to local news media. Individual campuses sponsored events aimed at students and the public, such as Onizuka and Veach Science Days of Discovery.

Core Criteria

As explained above, *our public outreach program enhances public understanding of science, technology, engineering, and mathematics and the NASA mission* through our online science magazine, public lectures, museum exhibit, many of our K-12 program (see section on precollege education), and other activities. *Planetary Science Research Discoveries* alone is geared to explaining the science behind research in planetary science.

Impact/Results

Our public outreach program has reached hundreds of thousands of people throughout the state and the world. Its success is measured by the numbers of people affected, by comments from the public, and by recognition from independent organizations.

Strengths and Weaknesses. Our main strength is the longevity and quality of our programs. Our online science magazine has been published since 1996. FFH, which contains a significant public outreach component, was established in 1990. Thus, when a local reporter needs information about a space mission or other newsworthy space event, they call the HSGC first. We are positioned to participate in large missions, both those being pursued by members of our consortium and those being developed by others. If we have a weakness, we do not have a systematic program of public speakers. However, HSGC staff give many public lectures that, unfortunately, we do not keep an accurate tally of.

Metrics to Demonstrate Success. We collect quantitative and qualitative information about the success of our programs. The best documented is *PSRD*. Most important is the endorsement of the Cosmochemistry Program that has funded the site since 1996. The site receives over 30,000 separate log-ins a month. The *PSRD* ranks second in google.com's directory of Earth Science Education links [http://directory.google.com/Top/Science/Earth_Sciences/Education/]. The public seems to enjoy the in-depth nature of the articles. *PSRD* is linked from numerous other sites about space and education. It has received awards from several organizations, such as the following (only a partial listing): (1) The National Academy Press selected *PSRD* in April, 2002 as a Cool Science Site. (2) The Teacher Information Network recognized *PSRD* with a Gold Award in April, 2001 "for excellence in utilizing the Internet as an empowering tool for quality education." [<http://www.teacher.com>]. (3) The National Science Teachers Association selected *PSRD* for sciLINKS in January, 2001. sciLINKS is an effort by NSTA to connect textbooks to online content.

The exhibit at the Bishop Museum was evaluated thoroughly. Besides being attended by over 100,000 people, the museum evaluated its effectiveness. The bottom line of the detailed report was that the exhibit was intriguing and clear to the public and to students of all ages.